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Realized Value Optimization in Product Development Post-certification

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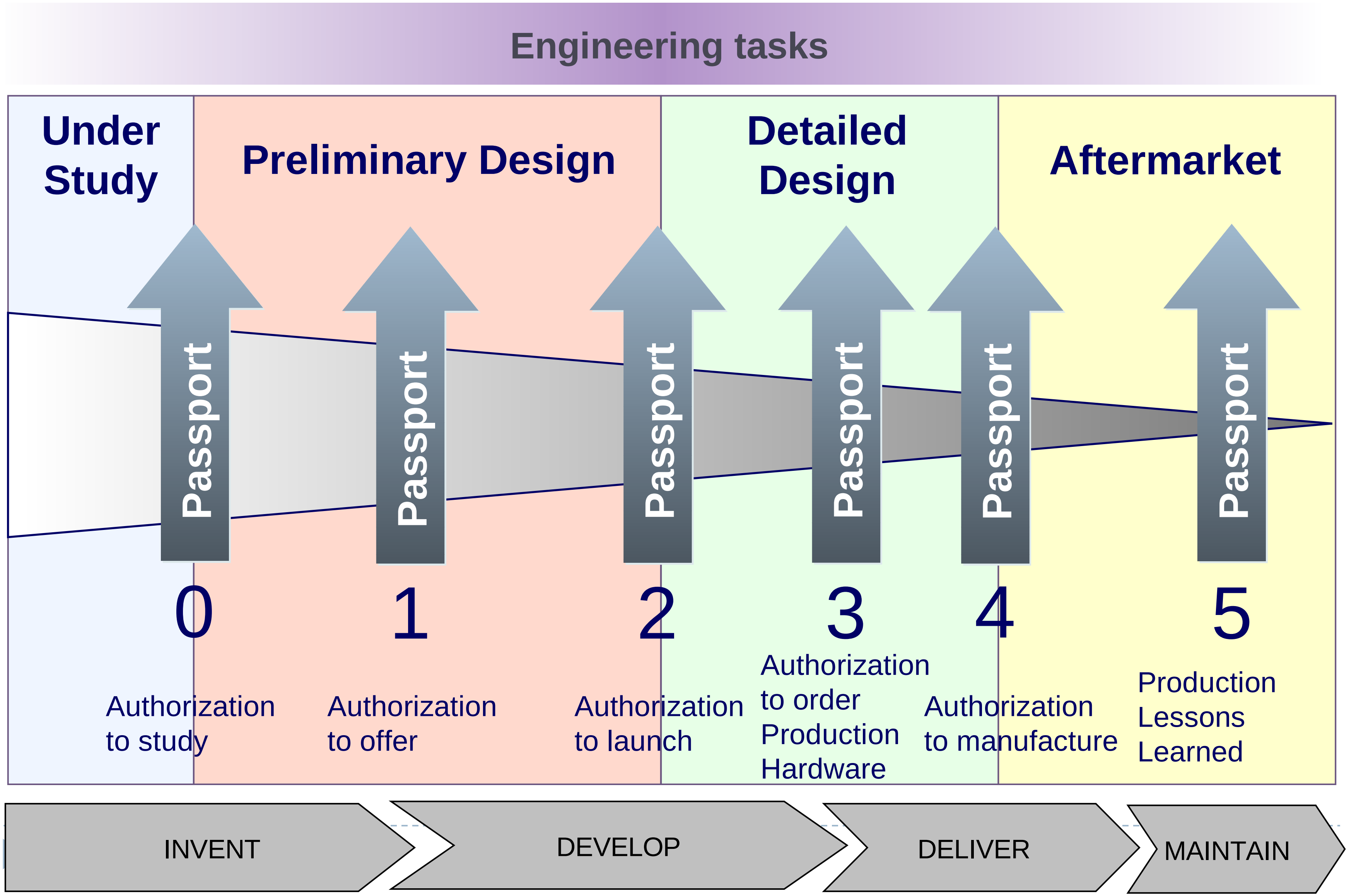
Plan

- Problem overview
- Model 1(mono period)
- Model 2 (multi periods)
- Model 3 (stochastic)
- Research perspectives

Problem context



P&WC Engineering Planning Cycle Overview

Programs list all desired tasks to be accomplished

Finance performs Consolidation of all tasks

If demand exceeds offer, high management needs to prioritize tasks

Tasks with low priority will be pushed to the following year

Objectives

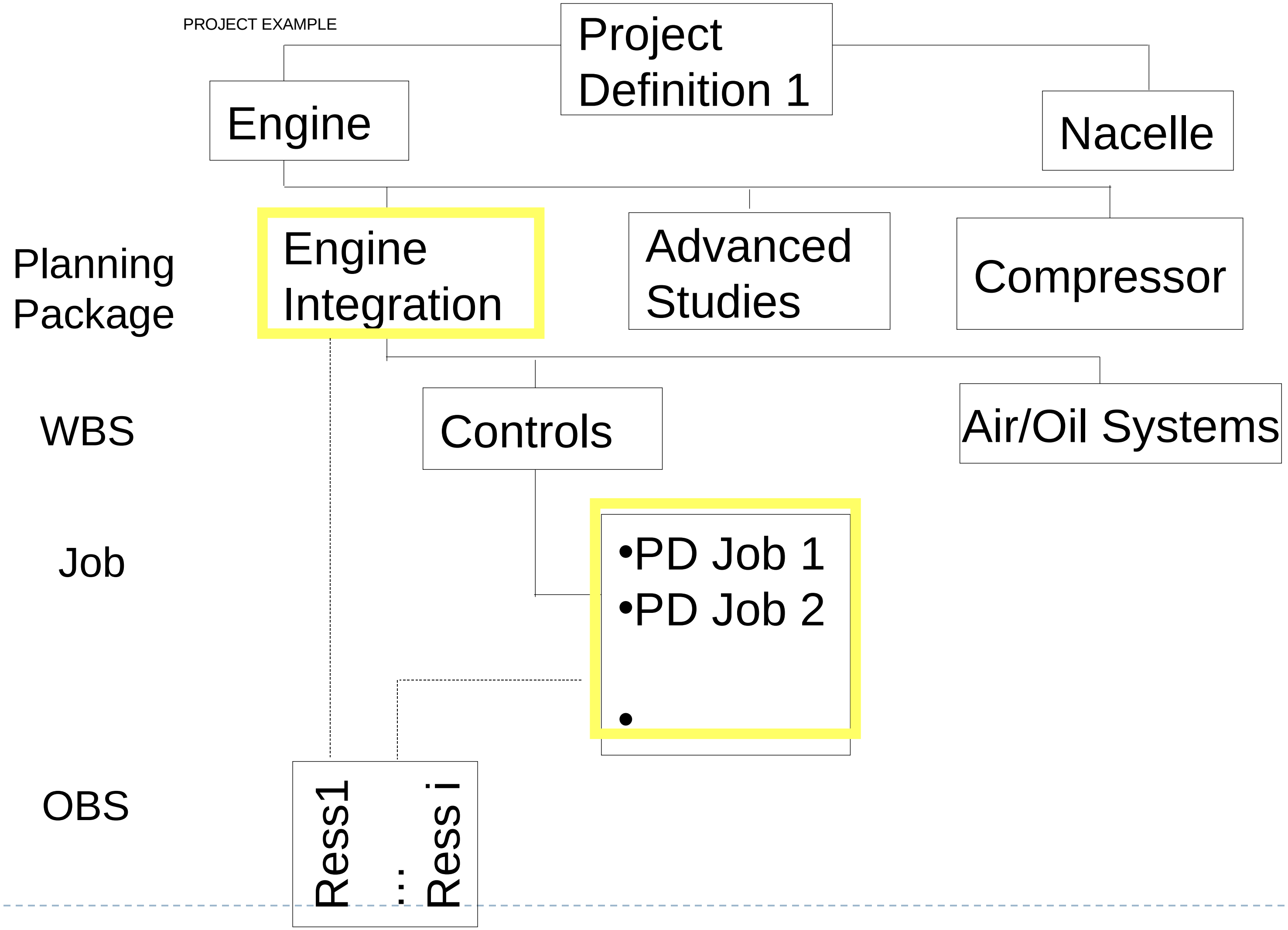
- Ensure projects demand balances with available resources
- Optimize project budgets for shareholder value
- Allocate available resources to enhance delivered value
- Enable more frequent planning with less effort

Lean approach for determining priority

Engineering task value (input) calculated based on:

- Customer impact
- Criticality of issue
- Work progress
- Impact on business

Definition of engineering tasks



Mono-Period Model

Sets definition

T : set of tasks

K : set of resource type

J : set of value criteria

H : set of activity type

P : set of projects

Parameters

D_{ik} : Quantity (hours) of resource $k \in K$ required to complete task $i \in T$

V_i : Value of task $i \in T$

δ_{ip} : 1 if task $i \in T$ is part of project $p \in P$, 0 otherwise

δ_{ih} : 1 if task $i \in T$ is an activity of type $h \in H$, 0 otherwise

C_k : Capacity (hours) of resource type $k \in K$

B_p : Budget (hours) of project $p \in P$

α_h : Minimum rate of task of activity type $h \in H$ to be completed

β_p : Maximum rate of project $p \in P$ Budget

γ_p : Minimum rate of project $p \in P$ Budget

Decision variables

O_i : 1 if we decide to complete task $i \in T$, 0 otherwise

Mono-Period Model

Objective function

$$max\left(\sum_{i \epsilon T} O_i \times V_i\right)$$

Maximize the realized value

Constraints

1. Capacity : $\forall k \epsilon K$

$$\sum_{i \epsilon T} O_i \times D_{ik} \leq C_k$$

Limited capacity per resource type

2. Total budget :

$$\sum_{\substack{i \epsilon T \\ k \epsilon K}} O_i \times D_{ik} \leq \sum_{p \epsilon P} B_p$$

Limited total budget for all projects

3. Project budget : $\forall p \epsilon P$

$$\gamma_p \times B_p \leq \sum_{\substack{i \epsilon T \\ k \epsilon K}} O_i \times \delta_{ip} \times D_{ik} \leq \beta_p \times B_p$$

Limited budget per project with respect to priority

4. Activities types : $\forall h \epsilon H$

$$\sum_{\substack{i \epsilon T \\ k \epsilon K}} O_i \times \delta_{ih} \times D_{ik} \geq \alpha_h \times \left(\sum_{\substack{i \epsilon T \\ k \epsilon K}} \delta_{ih} \times D_{ik}\right)$$

Priority given to some activities

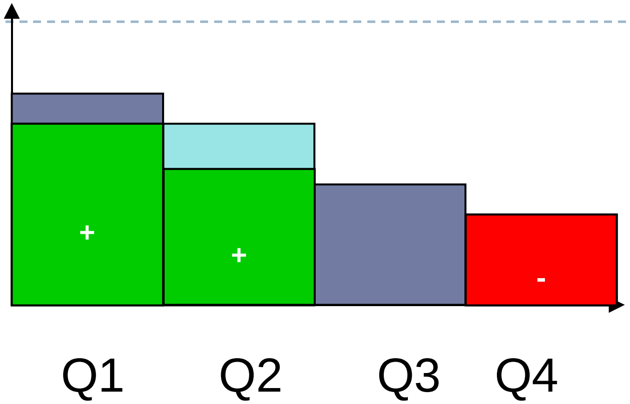
Mono-period: results obtained

- Solver
  - Solver: Xpress Mosel.

- 1st Data set (planning package level)
  - 377 tasks, 26 resource types
  - CPU time : 0,7 seconds

- 2nd Data set (job level)
  - 4000 tasks, 26 resource types
  - CPU time : 11 seconds

Multi-Periods Model



Sets definition

T : set of tasks
K : set of resource type
H : set of activity type
P : set of projects
Q : set of periods

Parameters

E_{ikq} : Estimated hours for task $i \epsilon T$ for resource type $k \epsilon K$ in period $q \epsilon Q$
C_{kq} : Resource type $k \epsilon K$ capacity (hours) in period $q \epsilon Q$
V_i : Value of task $i \epsilon T$
B_{pq} : budget (hours) for project $p \epsilon P$ in period $q \epsilon Q$
δ_{ip} : 1 if task $i \epsilon T$ is part of project $p \epsilon P$, 0 otherwise
δ_{ih} : 1 if task $i \epsilon T$ is an activity of type $h \epsilon H$, 0 otherwise
α_{hq} : Minimum rate of tasks of activity type $h \epsilon H$ to be completed in period $q \epsilon Q$
β_{pq} : Maximum rate of project $p \epsilon P$ budget in period $q \epsilon Q$
γ_{pq} : Minimum rate of project $p \epsilon P$ budget in period $q \epsilon Q$
P_{iq} : Penalty for task $i \epsilon T$ in period $q \epsilon Q$

Decision variables

X_{ikq} : worked hours for task $i \epsilon T$ for resource type $k \epsilon K$ in period $q \epsilon Q$
Y_{ikq} : earned value for task $i \epsilon T$, for resource type $k \epsilon K$ in period $q \epsilon Q$

Multi-Periods Model

Objective function

$$max\left(\sum_{\substack{i\epsilon T\\ q\epsilon Q}} V_i \times \left(\sum_{k\epsilon K} Y_{ikq}\right)\right) - \sum_{\substack{i\epsilon T\\ q\epsilon Q}} V_i \times P_{iq} \times \left(\sum_{k\epsilon K} X_{ikq}\right)$$

Maximize the realized value

Constraints

1. Capacity constraint : $\forall(k,q)\epsilon K \times Q$

$$\sum_{i\epsilon T} X_{ikq} \leq C_{kq}$$

Limited capacity per resource type per period

2. Minimum (E, X) : $\forall(i,k,q)\epsilon T \times K \times Q$

$$Y_{ikq} \leq E_{ikq}$$
$$Y_{ikq} \leq X_{ikq}$$

Earned value limits

3. Respect estimated hours : $\forall(i,k)\epsilon T \times K$

$$\sum_{q\epsilon Q} X_{ikq} = \sum_{q\epsilon Q} E_{ikq}$$

Respect estimated hours

4. Total budget constraint : $\forall q\epsilon Q$

$$\sum_{\substack{i\epsilon T\\ k\epsilon K}} X_{ikq} \leq \sum_{p\epsilon P} B_{pq}$$

5. Project budget constraint : $\forall(p,q)\epsilon P \times Q$

$$\gamma_{pq} \times B_{pq} \leq \sum_{\substack{i\epsilon T\\ k\epsilon K}} \delta_{ip} \times X_{ikq} \leq \beta_{pq} \times B_{pq}$$

Budget constraints

6. Activities types constraints : $\forall(h,q)\epsilon H \times Q$

$$\sum_{\substack{i\epsilon T\\ k\epsilon K}} \delta_{ih} \times X_{ikq} \geq \alpha_{hq} \times \left(\sum_{\substack{i\epsilon T\\ k\epsilon K}} \delta_{ih} \times E_{ikq}\right)$$

Priority given to some activities

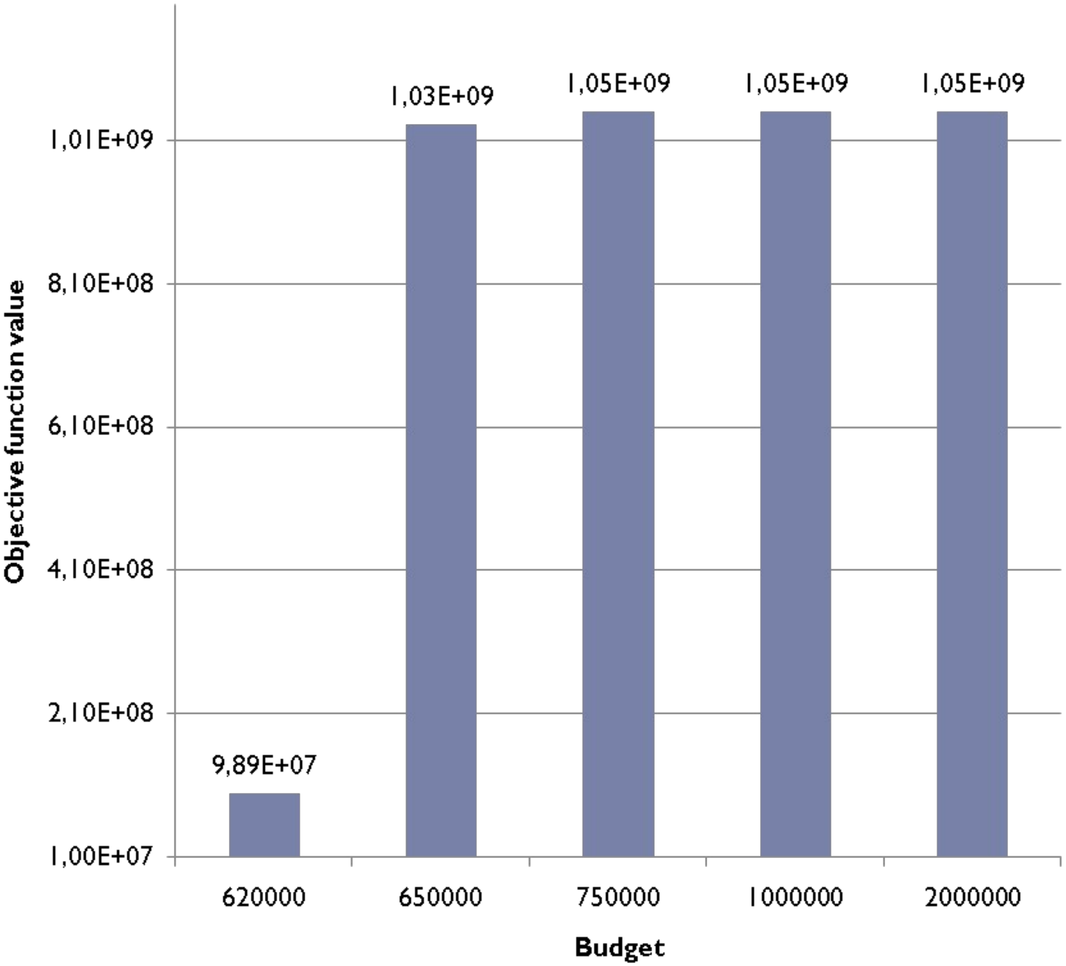
7. Positivity constraints : $\forall(i,k,q)\epsilon T \times K \times Q$

$$X_{ikq} \geq 0$$
$$Y_{ikq} \geq 0$$

Multi-periods: results obtained

- Data set (job level)
  - 4000 tasks,
  - 26 resource types
  - 1 664 000 variables
  - CPU time : 34 seconds

- Solver
  - Solver: Xpress Mosel.



Stochastic models

1st: Dynamic program model

2nd: Hybrid solution: Genetic/simulation (programmed in Ruby)

- Genetic algorithm: jobs priority
- Simulation: evaluation function using a sequential scheduling approach

3rd: Stochastic gradient descent (programmed in Ruby)

1. generate random priority vector
2. evaluate the solution
   - for each quarter, task and resource
     - x = min (estimate, remaining capacity for resource k)
     - x = min (x, remaining total budget)
     - x = min (x, remaining budget for task i project)
     - update remaining capacity, budgets
     - update cost function
     - postpone remaining estimate
3. update the best known solution if better
4. switch 2 tasks of the best known solution
5. go to 2
6. if after 10 trials we don't improve the best known solution, go to 1

Conclusion

- Workshop objectives
  - ↻ Validate the initial model
  - ↻ Propose a multi-period model
  - ↻ Obtain a feasible solution with real data within a reasonable time period

- Research perspectives:
  - Test the multi-period model at the activity level
  - Expand and test the stochastic models